

SPECIFICATION**METHOD, MOBILE STATION AND BASE STATION FOR CONNECTION
SETUP IN A RADIO COMMUNICATION SYSTEM**BACKGROUND OF THE INVENTION

The invention is directed to a method for connection setup before a mobile station of a radio communication system as well as to a mobile station configured in this way and to a base station.

The establishment of digital radio communication systems is disclosed in J. Oudelaar, "Evolution Towards UMTS", PIMRC 94, 5th IEEE International Symp. on Personal, Indoor and Mobile Radio Communications, the Hague, NL, 18 through 22 September 1994, pages 852 through 856, and M. Lenti, H. Hageman, "Paging in UMTS", RACE Mobile Telecommunications Workshop, Vol. 1, Amsterdam, NL, 17 through 19 May 1994, pages 405 through 410.

The presently existing mobile radio telephone system GSM (Global System for Mobile Communications) is a radio communication system with a TDMA component for subscriber separation (time-division multiple access). Payload information of the subscriber connections are transmitted in time slots according to a frame structure. The transmission ^{occurs} ~~ensues~~ block-by-block. Frequency channels adapted to the time grid of the frame structure (RACH random access channel) are also known from the GSM mobile radio telephone system for arbitrary access for the mobile stations. A mobile station that requests a connection setup can send an access radio block in this frequency channel without a frequency channel having been previously allocated to the mobile station. A transmission power control cannot ^{occur} ~~ensue~~ given random access, since the transmission conditions are not yet known at the transmitter side. A mobile station therefore usually sends with maximum transmission power for the radio cell. Maximum transmission power is also selected in order to assure that a mobile station located at the edges of the radio cell that transmits an access radio block generates a signal at the base station that is strong enough for a detection. When a plurality of mobile stations simultaneously actuate the random access in the

same time slot and frequency band, radio blocks lower in power would not be capable of being interpreted and would have to be re-transmitted at a later point in time by the affected mobile stations. When two or more signals having nearly the same power intensity arrive, both signals may possibly not be detected and must be re-initiated.

> SUMMARY OF THE INVENTION

The invention is based on the object of offering a method and devices that enable the connection setup for the random access of the mobile stations in a radio communication system given optimally effective utilization of the radio-oriented resources. This object is achieved ~~by the method~~ comprising the features of patent claim 1, the mobile station comprising the features of patent claim 16 and the base station comprising the features of patent claim 17. Developments of the invention can be derived from the subclaims.

The radio communication system having at least one base station provides that frequency channels for a random access be offered in recurring fashion for the mobile stations in upstream direction. A reception power of a signal transmitted in downstream direction from the base station is measured by the mobile station that requests a connection setup, and a transmission power for sending an access radio block to the base station is set dependent on the measured reception power.

A flexible transmission power control can thus ^{occur} ~~ensue~~ at the side of the mobile station with the assistance of the measured reception power of the signal transmitted at the base station side, this also ^{occurring} ~~ensuing~~ for the random access of the mobile station, this having hitherto not been available. As a result of the setting of the transmission power for the random access, a plurality of such accesses can simultaneously ^{occur} ~~ensue~~ from different mobile stations without the other signals that are active in the same frequency band or on neighboring carriers being thereby disturbed or possibly being no longer detected. Neighboring channel interferences are reduced or, respectively, eliminated by the flexible power control for the access radio block or blocks, which need not be transmitted with maximum transmission power in every case. Due to the increased rate of successful detections of

the access radio blocks that are transmitted - equivalent with a lower rate of reoccurring access attempts due to inadequate detection - , the radio-oriented resources are utilized better. Overall, the connection setup is also accelerated since fewer access attempts of the mobile station are needed until a successful connection setup has been achieved.

The invention can be particularly advantageously employed in a TD/CDMA radio communication system, since the access radio block is active in the same frequency band simultaneously with other payload signals - for example, traffic data or signalling information or organization information. The information of various connections can thereby be distinguished from one another and a frequency channel formed by the time slots on the basis of a connection-individual fine structure. This fine structure preferably comprises codes with which the individual subscriber signals are spread.

Over and above this, the invention leads to advantages where the principle of random access is modified such that the multiple access - preferably according to TD/CDMA - also occurs on neighboring carriers, so that high neighboring channel interferences are to be expected at the base station side given highly different reception powers of the different access radio blocks. It is precisely this that can be avoided by the invention, since great differences in the reception power are - from the point of view of the base station - compensated by the flexible transmission power control in the mobile station.

The above advantage derives when, according to a development of the invention, a broadband frequency range is divided into sub-ranges with narrower bandwidth within the frequency channel for the random access, the mobile station that requests the connection setup selecting one sub-range within the frequency channel and sending the access radio block to the base station in this sub-range.

In the transmission of the access radio block, this can be spread with an individual code at the transmitter side, so that a plurality of random accesses can also occur as warranted in one sub-range. Advantageously,

the individual code represents the random number of the access block and can be selected from a set of allowed codes that are known to the receiving station. Alternatively thereto, it can be provided that the access radio block is not spread. The evaluation thereof is facilitated.

5 According to another development of the invention, the transmission power is set all the higher by the mobile station the lower the measured reception power is. The mobile station can thus optimally adapt the power to the conditions of the transmission link.

10 It has proven advantageous to estimate a radio field attenuation in ^{the} downstream direction with the mobile station on the basis of the measured reception power, and to set the transmission power such that the radio field attenuation is at least partially compensated.

15 The signal transmitted in ^{the} downstream direction with reference whereto the reception power can be measured can be a training sequence signal, a data signal, a pilot signal or a control signal transmitted on the BCCH channel according to advantageous developments.

20 It is also advantageous when at least one auxiliary information is inserted into the signal transmitted in downstream direction, this being employed by the mobile station for setting the transmission power. The auxiliary information is preferably composed of an information about the transmission power used by the base station in downstream direction. The mobile station thus receives an information that it can directly employ for setting the transmission power suitable for the individual case and that it can additionally interpret for measuring the reception power.

25 The invention is explained in greater detail below on the basis of an exemplary embodiment with reference to graphic illustrations.

BRIEF DESCRIPTION OF THE DRAWINGS

[^] Thereby shown are:

- 30 FIG. 1 ^{is} a block circuit diagram of a mobile communication system for connection setup for random accesses of ^a mobile station;
- FIG. 2 ^{is} a schematic illustration of the frame structure for the radio transmission;

FIG. 3 ¹⁵ a schematic illustration of the division or frequency channel for random access into sub-ranges; and

FIG. 4 ^{shows} block circuit diagrams of ^{the} mobile station and ^{the} base station.

[>] DESCRIPTION OF THE PREFERRED EMBODIMENTS

In terms of structure, the mobile communication shown in FIG. 1

corresponds to a known GSM mobile radio telephone system that comprises a plurality of mobile switching centers MSC that are ^{networked} network with one another or, respectively, that produce the access to a fixed network PSTN. Further, these mobile switching centers MSC are respectively connected to at least one base station controller BSC. Each base station controller BSC in turn enables a connection to at least one base station BS. Such a base station BS is a radio station that can setup message connections to mobile stations MS via a radio interface. An operation and maintenance center OMC realizes operation and maintenance functions for the mobile radio telephone network or, respectively, for parts thereof. Three connections for transmitting payload information and signalling information between three mobile stations MS1, MS2, MS3 and a base station BS are shown by way of example in FIG. 1. The functionality of this structure can be transferred onto other radio communication systems wherein the invention can also be utilized.

The mobile stations MS can ^{initiate} initiate a random access in ^{the} upstream direction on their own without a frequency channel having been previously allocated to the mobile station. For supporting the random access, the system respectively offers frequency channels (rach, random access channel) adapted to the time grid of a frame structure used for radio transmission. A mobile station that requests a connection setup can send an access radio block rab in this frequency channel. ^{According to the invention} Inventively, the mobile station MS that requests a connection setup measures the reception power r_p of a signal s_s sent in ^{the} downstream direction from the base station BS, and sets a transmission power t_p for sending the access radio blocks rab dependent on the measured reception power r_p . The signal s_s is made available to the base station BS by a signal processing ^{unit} means SP, is provided with a transmission power r_p' by a control ^{unit} means SP of the base station BS, and is transmitted to the mobile station via the radio interface.

The signal ss with reference where to the reception power rp can be measured by a signal processing ^{unit} means SP of the mobile station MS can - according to advantageous solutions, ^{unit} be a training sequence signal tss given employment of a TD/CDMA radio transmission (see FIG. 2), a data signal ds , a pilot signal ps or a control signal bsc transmitted on the BCCS channel (broadcast channel). The transmission power tp for the access radio block rab is preferably set all the higher by a control ^{unit} means ST of the mobile station MS the lower the reception power rp measured by the signal processing means SP is.

Additionally, there is the version for the mobile station MS to have an auxiliary information zui inserted into the signal ss by the base station BS and transmitted via the radio interface interpreted by the signal processing means SP in order to have optimally many parameters available for transmission power control for the random access. The auxiliary information zui , which is preferably composed of an information about the transmission power rp' set ^{the} in ^{unit} downstream direction is used at the mobile station side for setting the transmission power for sending the access radio block rab .

In collaboration with the control ^{unit} means ST , the signal processing ^{unit} means SP implements an estimation of the radio field attenuation of the connection between base station BS and mobile station MS on the basis of the measured reception power rp , implementing this over and above the former. The transmission power tp is subsequently set such that the identified radio field attenuation can be at least partially compensated. A complete compensation control of the radio field attenuation is likewise possible. The overall attenuation of the transmission channel employed is composed of a separation attenuation, of the shadowing and of the rapid fade. A limited leveling of the radio field attenuation estimated from measuring the power has the advantage with respect to the two first-cited cases that other signals that are simultaneously active in the same frequency band - such as, for example, payload information (see FIG. 2) or further access radio blocks (see FIG. 3) - are only slightly disturbed by the transmitted access radio block rab . When, despite the power setting taking

the momentary transmission conditions into consideration, the random access has not been detected at the initial attempt - for example, due to a currently strong attenuation given rapid fade-, a renewed random access can be initiated by the mobile station MS with slightly increased transmission power tp .

The above comments apply correspondingly to other mobile stations MS that wish to start the random access simultaneously or offset in time. The method of the invention yields advantages precisely when a plurality of mobile stations actuate the random access in the same time slot and frequency band in which other signals are active. A transmission of the access radio block rab with maximum transmission power would result in extreme interference and a non-detection of these other signals. This disadvantage can be avoided by the flexible control of the transmission power tp for sending the access radio block rab in each mobile station dependent on the measured reception power of the received signal ss on the individual connection.

The frame structure of the radio transmission is described in FIG. 2 with reference to the example of a combined TD/CDMA method but can also be applied without further ado to ^{the} other radio transmission method - for example, continuous methods such as DS-CDMA (direct sequence CDMA). The invention is also not limited thereto that a plurality of connections simultaneously exist between mobile stations and one or more base stations. The signals also need not be capable of being distinguished from one another by a connection-individual fine structure; rather, for example, they can be separated by time slots. According to a TDMA component of the TD/CDMA method, a division of a broadband frequency range B - for example, $B = 1.6$ MHz - into a plurality of time slots ts , for example eight time slots $ts1$ through $ts8$, is provided. Each time slot ts within the frequency range B forms a frequency channel FK . Information of a plurality of connections are transmitted in radio blocks within frequency channels FK (tch) that are provided for payload data transmission. These radio blocks for payload data transmission are composed of sections having data d in which

sections having training sequences tseq1 through tseqK known at the reception side are embedded. The data d are connection-individually spread with a fine structure, a subscriber code c, so that, for example K connections can be separated by these CDMA components at the reception side.

5 The spread of individual symbols of the data d effects that Q chips having the duration T_{chip} are transmitted within the symbol duration T_{sym} . The Q chips thereby form the connection-individual subscriber code c. A guard time gp for compensation of different signal running times of the connections is also provided within the time slots ts.

10 The successive time slots ts are divided according to a frame structure within a broadband frequency range B. Thus, eight time slots ts are combined into a frame, whereby, for example, one time slot ts4 of the frame forms a frequency channel FK (tch) for payload data transmission and is recurringly used by a group of connections. One frequency channel FK (rach) for the random access of the mobile stations MS is not offered in each frame but is offered at a predetermined point in time within a multi-frame. The spacings between the frequency channels FK (rach) for the random access determine the capacity that the mobile communication system makes available for this part of the connection setup. According to the exemplary embodiment, the transmission of the access radio block rab is provided in the time slot ts1. The signal sent in downstream direction for measuring the reception power and that is employed by the mobile station for setting the transmission power can be taken in a simple way as data signal ds from the data d or as training sequence signals tss of the training sequence of a radio block transmitted in downstream direction, so that no additional seizure of radio-oriented resources is required for this purpose.

25 FIG. 3 shows the structure of the frequency channel FK (rach) for random access. The broadband frequency range $B = 1.6$ MHz that, for example, is calculated from the frequency band of an organization channel of the mobile communication system charged with the duplex spacing, contains four sub-ranges UB each having a respective bandwidth of, for example, 200 kHz that are respectively separated by a range of 200 kHz in

order to reduce mutual disturbances. Access radio blocks rab can be sent within the sub-ranges UB as needed by mobile stations MS without prior allocation at the network side and without spreading. Access radio blocks according to the GSM standard can thus be employed. Given an alternative division of the frequency channel FK(rach) for random access, a total of eight sub-ranges UB are realized; these can overlap in terms of frequency. For better discrimination, the access radio block rab are spread with an individual code c1 but can also be fundamentally transmitted without spread.

The access radio block rab is shorter compared to the radio blocks for payload data transmission according to FIG. 2, the guard time is lengthened. This is necessary in order to assure a reliable reception in the base station BS despite the time synchronization having not yet ^{occurred} ensued. The access radio block rab is beamed out with the transmission power that can be variably set according to the invention. The access radio blocks rab contains a bit sequence f1 known at the reception side for time synchronization and contains a random number f2. On the basis of the known bit sequence f1, the base station BS can determine the presence of an access radio block rab and can undertake a first time synchronization from the point in time of the arrival. The random number f2 selected by the mobile station MS, which can simultaneously represent a reference to the individual code c for spreading the access radio block rab, is used as reference for the following allocation of a frequency channel FK for further signalling for the connection setup. The mobile station MS can recognize the allocation addressed to it with this random number f2.

FIG. 4 shows the structure of a mobile station MS as well as of a base station BS with the devices required for the invention. The base station BS can detect and evaluate the access radio blocks transmitted in the frequency channels for the random access and can undertake a subscriber separation and a detection of the subscriber data for the payload information transmitted in the frequency channels.

^{unit} The mobile station MS contains a control panel T, a signal processing ^{unit} means SP, a control means ST and a transmission/reception ^{unit} means SE/EE.

The subscriber can undertake inputs at the control panel T, including an input for a connection setup request. An access radio block rab is formed in the signal processing ^{unit} means SP and is transmitted via the transmission/reception ^{unit} means SE/EE with the transmission power rp ^{unit} ~~is~~ set in the control ^{unit} means ST. The control ^{unit} means ST selects the sub-ranges within the nearest possible frequency channel for random access according to the above-described principles. The access radio block rab - following a corresponding signal editing - is sent narrow-band in the selected sub-range by the transmission ^{unit} means SE. Previously, the signal processing ^{unit} means SP interprets the signal ss that has arrived via the transmission/reception ^{unit} means SE/EE, in that it measures the reception power rp thereof and ^{unit} ~~communicate~~ communicates this to the control ^{unit} means ST. For example, the measurement of the reception power ^{unit} ~~ensures~~ occurs by summing up the squares of the samples of the received signals ss - in the digital - or by integration over the squares of the signal amplitudes - in the analog - or by summing up the estimated samples of the channel pulse response. This is carried out in the signal processing ^{unit} means SP. The determination of an estimated value for the reception power can also be interpreted as measurement. The auxiliary information zui potentially contained in the signal ss is likewise interpreted by the signal processing ^{unit} means SP and made available to the control ^{unit} means ST for controlling the transmission power.

The base station BS contains a transmission/reception means SE/EE that amplifies reception signals, converts them into the base band and demodulates them or, respectively, that modulates transmission signals like the signal ss, and edits them for the high-frequency emission. A signal processing ^{unit} means SP that, for example, comprises a GD processor as digital signal processor for detecting arriving payload information and signalling information according to the JD-CDMA method (joint detection) also interprets the access block or blocks rab. The signal ss that is to be beamed out in downstream direction is provided with the transmission power rp' ^{unit} ~~is~~ by a control ^{unit} means ST and is incorporated into a radio block according to FIG. 2 as data signal or training sequence signal. When this is a matter of

a pilot signal, it is sent independently of a payload data transmission - preferably continuously. Given employment of the BCCH control signal, the signal ss is incorporated as control signal by the control means ST and, for example, is sent to the mobile station MS as organization information.

5 The separation of the various sub-ranges ensues with a filter bank and an individual interpretation of the access block rab in the respective sub-ranges subsequently ensues. Alternatively, a prior low-pass filtering can be foregone and a detection can be implemented broad-band with a single user interpretation or with a joint detection interpretation.

10 The interpretation ensues by determining the correlation between the received signals and the bit sequences known in the base station BS (see FIG. 3). The point-in-time of the greatest correlation is thereby also identified, this serving subsequently for time synchronization. Alternatively, a signal-adapted filtering or some other linear algorithm (for example, according to the zero forcing or the minimum square error criterion) can also be applied.

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